Journal of Research and Rural Planning
Volume 12, No. 2, Spring 2023, Serial No. 41, Pp. 55-72
eISSN: 2783-2007 **ISSN: 2783-2791**
http://jrrp.um.ac.ir

Original Article

Investigating the Changes in Spatial Pattern of Rural Settlement Network of Qazvin Province with the Emphasis on the Role of Ecological Elements During the Period 1976-2016

Akbar Mohammadi [1*]

1- Assistant Prof. in Architecture, Buein Zahra Technical University, Buein Zahra, Iran

Abstract
Purpose- Initial and preliminary review of distribution of rural settlements of Qazvin province indicates a special pattern in this province (the densely populated villages in some areas of the province and being devoid of population in some other villages) which has been changed during different census periods and it raises the following questions: what factors have created such a pattern? Do ecological factors play a role in the formation of this pattern? Hence, the purpose of the present study is to answer these questions.
Design/methodology/approach- The present study was conducted using a descriptive-analytical method. First, the Getis-Ord Gi* statistic was used to review the spatial pattern of rural residents' network in Qazvin province, then k'luster analysis method through edge removal (SKATER) was used for grouping rural areas based on ecological conditions, and finally using the obtained results, the correlation coefficients between the ecological factors and the spatial distribution of the population in the obtained ecological groups were calculated .
Findings- examining the spatial distribution pattern of rural settlements of Qazvin province according to Getis-Ord statistic indicates a cluster pattern of population spatial distribution in rural areas of Qazvin province. This pattern has high density in some areas and low density in other areas. The central parts of the province which include the Qazvin plain, have hot spots, and the northern areas of the province which include the mountainous areas, have cold spots. Based on the ecological grouping of villages through SKATER method and calculated correlation coefficients, the highest impact belonged to the grouping related to access to underground waters (existence of aquifer) and the next ranks belong to the distance from the river and slope. This shows the high impact of ecological variables on the distribution of rural population of the province during different periods.
Keywords: Spatial pattern, Rural settlements, Ecological factors, SKATER method, Qazvin province.

Use your device to scan and read the article online	How to cite this article:	Date:
	Mohammadi, A. (2023). Investigating the changes in spatial pattern of rural settlement network of Qazvin province with the emphasis on the role of ecological elements during the period 1976-2016. *Journal of Research & Rural Planning*, *12*(2), 55-72. http://dx.doi.org/10.22067/jrrp.v12i2.2207-1054	*Received: 30-10-2022* *Revised: 22-12-2022* *Accepted: 12-02- 2023* *Available Online: 12-02-2023*

Corresponding Author:
Mohammadi, Akbar, Ph.D.
Address: Department of Architecture and Urban Planning, Faculty of Architecture, Buein Zahra Technical University, Buein Zahra, Qazvin, Iran
Tel: +982833894480
E-Mail: a.mohammadi@bzte.ac.ir

1. Introduction

N The spatial distribution of human settlements in different spatial levels (national, regional, and sub-regional) are affected by different ecological, social, economic, political and other factors of that period and place. At the beginning of human story, the distribution of pattern of rural settlements has been mostly influenced by ecological factors such as access to water and suitable slope. Early humans chose the place of their settlements where they could access their needs and at the same time be safe from natural disasters. Choosing caves near the rivers as the first places of human settlement shows the significance of ecological factors and it is proved by numerous researches of archaeologists. For instance, the study by Mousavi Kouhpar et al., (2011) showed the high impact of natural environment on residential patterns in different ancient periods of Mazandaran province. Bahrami et al., (2016) examined the effect of natural factors on the distribution of ancient habitats in Ardabil province and the results showed a significant relation between land vegetation and slope and dispersion distribution of this settlements. In another research, Rezaee (2015) investigated the role of environmental factors in Bakun period settlements in Kazeroun plain and the results indicated a strong relationship between the settlement patterns of Bakun period and the slope classes and vegetation.

With the change in human's life and technological and technical advances made by humans in recent centuries in addition to ecological factors, economic, social, and political factors (and other factors such as population distribution policies by governments, investment in different economic sectors, income, employment, etc.) are also involved in the spatial distribution of human settlements. Despite the decrease in the role of ecological factors during the contemporary period, these factors are still strong and undeniable, especially in the rural settlements of developing countries such as Iran, whose way of life and livelihood depends on water and soil resources. ecological resources such as water, height and slope changes, soil, precipitation, etc. influence the spatial distribution and size of these settlements.

Qazvin is one of the provinces of Southern Alborz, where the settlement dates back to 4500 to 6000 years BC (Fazli Nashli et al. 2011). Initial and preliminary review of distribution of rural settlements of Qazvin province indicates a special pattern in this province (the high density of rural population in some areas of the province and being devoid of population in some other villages) which has changed during different census periods and it raises these questions: what factors have created such a pattern? ? Do ecological factors play a role in the formation of this pattern? Hence, the purpose of the present study is to answer these questions.

The necessity of such research can be seen in the better identification of planning environments for regional and rural planners and relevant managers, which helps them in identifying and making policies related to villages.

2. Research Theoretical Literature

The accommodation pattern in the rural settlements of each region is more than anything a reflection of the characteristics of the natural environment (weather, vegetation, environment, how to access water and resources, spatial dispersion of water networks and the quality of soil) (Saeedi, 2009). Also, based on hydraulic theory, the main factors in the emergence of settlements have been the irrigation of arable land, population increase and its density in natural favorable areas (Shakoei, 2010). Numerous studies have been conducted on the impact of ecological conditions on residential patterns, especially the rural settlements. Among these researches, the following can be mentioned:

Liu et al. (2022) in their study reviewed the distribution of villages in Jiangxi province in China in relation with some natural factors such as height, slope, distance from the river, soil resources and some man-made factors including distance from the road and the effect of nearby cities. In this study methods such as Kernel density, spatial autocorrelation (SA) and modeling approaches such as simple and multiple linear regression analysis were used. Findings of the research showed that, rural settlements in the study area have a spatial distribution pattern of "dense north and scattered south" and the investigated factors play a great role in the distribution pattern of villages. According to this, a new rural development inequality assessment index, i.e. socio-environmental assessment index, (SEI) was created. Areas with an SEI index of less than 0.40

should be prioritized for the implementation of the revitalization strategy in this province.

In a study conducted by Zhang et al. (2021) the relationship between the climate and spatial distribution of rural population in Poyang lake area was examined. Spatial autocorrelation and spatial regression modeling methods were used in this study. The results of this research also indicates a significant relationship of spatial correlation between distribution of rural population and climatic factors and the role of climatic factors is greater than economic factors.

In a research, Zhang et al. (2020) investigated the evolution and factors affecting the distribution pattern of China's rural population since 1990 using the geographical detector method. In this research, natural, social, and economic data were used to identify the distribution pattern. The results of the study indicated that the distribution of the rural population of China is a function of natural, social, and economic conditions, and among the natural factors, the potential efficiency of product and the degree of surface fragmentation have had the greatest impact.

In a study carried out by Guanghui et al. (2007) factors affecting the change of villages in mountainous areas of Beijing were examined. Logistic regression method and GIS and SPSS were used in this study. The results show the effective and obvious role of natural, accessibility and economic factors in the location selection and changes of the villages in these areas.

Ma et al. (2012) in their research article examined the spatial and temporal distribution of rural settlements in Gangu region in China during 1998-2008. The data of landset 5 remote sensing satellite and SPOT were used in this study and the results showed that, there was a strong relationship between the location of rural settlements and height, slope, traffic and water resources and the villages were mainly located in areas with low height, gentle slope and near the road or the river.

Xoe-Lan et al. (2010) in their study investigated and analyzed the factors affecting the spatial distribution of rural settlements in Mayang town in China, using GIS and spatial analysis techniques and landscape analysis indices. The findings of the research show the impact of natural, socio-economic, and productive environmental factors on the spatial distribution of these settlements.

Chen et al. (2022) in a study reviewed the spatial pattern of settlements and factors influencing the formation of this pattern in Qinba mountainous area in Shanxi province in China. The data analysis of this research has been done by GIS using landscape and spatial distribution analysis indices. The results show that, there is a strong and significant relationship between the spatial distribution pattern of rural settlements in this area and the influential factors such as shape of the land, slope, distance from urban centers, distance from main roads, and distance from main rivers.

Shahi (2021) in a study has examined the distribution of rural settlements and influential factors in Har Ki Dun region in Himalaya Mountains. This area is a high mountainous area with a rural population of 22000 people. The results of this study also indicates the high impact of factors such as slope and height on the spatial distribution and size of settlements in this region.

In a study conducted by Wang et al. (2020) the spatial distribution pattern of small cities and factors affecting the formation of this pattern in China were investigated. The findings of this study show a certain pattern in spatial distribution of small cities in China. Several factors including natural environment, population density, level of economic development, location advantage, road traffic conditions, and political factors are involved in the formation of this pattern.

In a study by Qiu et al. (2019) the spatial distribution pattern of rural settlements in the high hills of southern Jiangxi located in Chongqing country, China, was investigated and analyzed in relation to various natural and social factors. Findings show the high density of rural areas in the north and low density in the southern area. This pattern is significantly influenced by height changes, distance from the river, and distance from roads.

Xo et al. (2021) in a study examined the distribution pattern of villages in Shaanxi, China. In this study in order to review the spatial distribution and evaluate its relationship with the influential factors, spatial metrics and spatial autocorrelation were calculated using GIS. The results indicated the clustering pattern in the spatial distribution of rural settlements in the region. Factors influencing the formation of this pattern were geomorphological conditions, population and land use.

In an applied research Tao et al. (2017) examined the macro climatic factors in the formation of spatial distribution of rural settlements in eastern China. Single variable point pattern analysis

method was used in this study. The statistical modeling of this study showed that, on a macro scale, potential evaporation and transpiration and topographic heterogeneity had negative impact on the size of the realm, while they had positive effects on territorial clustering.

Sadr Mousavi et al. (2017) in a study investigated the role of natural factors on geographical distribution of rural settlements in terms of numbers in Sahneh town using overlay analysis in GIS system and regression analysis. The natural factors indices included height, slope, climate, water resources, soil resources, vegetation, and land use. The results showed that, natural factors play an important role in the location of rural settlement in Sahneh town and the greatest impact was related to water and soil resources.

In another research, Aliaee (2018) examined the role of natural factors in the distribution and establishment of rural settlements in Zanjan city. Overlay analysis and Moran's I in GIS system and calculating correlation coefficient methods were used in this study. The results showed that, there was a weak relationship between natural factors (height, slope, slope direction, precipitation, and temperature) and location and establishment of rural settlements in Zanjan city.

In their research paper,Motiee langroudi et al. (2016) analyzed the spatial distribution of rural settlements in Sabzevar-Neishabour region based on ecological resources. Overlay analysis in GIS and zoning methods were used in this study. The results showed a high correlation between ecological elements and the number of villages in the created areas.

In a study titled "reviewing the role of natural factors in geographical distribution of population and urban settlements using GIS and Geoda", Mousavi et al. (2012) analyzed the role of natural factors in the population distribution in cities of west Azarbaijan. The results showed a strong and significant relationship between climate and access to water resources with population density of cities of the province.

Nematullahi and Ramesht (2021) in a study analyzed the spatial distribution of rural settlements according to natural factors (height, slope, slope direction, convex and concave surfaces, earth surface temperature, precipitation, and relative humidity in Iran. Overlay analysis in GIS system was also used in this research and descriptive method was used for data extraction. The results indicate that, spatial arrangement pattern of rural settlements is related to formative systems and morphologic-climatic components.

Estelaji & Jafari (2014) in their study investigated the role of natural factors in spatial arrangement of rural settlements in Mahneshan town. Overlay analysis in GIS and calculation of correlation coefficient were used in this research. The results of this study also showed a strong relationship between some indices of natural environment such as slope, elevation classes, and climate and spatial distribution and number of rural settlements.

In a general summary, it can be said that, the ecological factors affecting the spatial pattern of settlements especially rural settlements according to the conducted studies include climatic factors and variables, height, slope, slope direction, water and soil resources. Land use is mentioned in some studies and it seems that, it is a phenomenon resulted from ecological factors and cannot be considered as an ecological factor.

Some of these factors directly and some indirectly affect the spatial distribution pattern of rural settlements. The effect of these factors and variables is presented in diagram number 1.

The difference between the present study and similar studies mentioned in research literature can be stated as follows:

As observed in research conducted on the subject under study, in most studies spatial pattern of rural settlements has been examined in the form of geographical distribution without considering the population of these settlements. In rare cases, the population factor in this pattern has been examined cross-sectionally and in a specific year, while in the present study population changes in a 10-year periods (40 years) were used to review the spatial changes of rural settlement network.

The second difference between this study and other studies is the factors influencing the formation of rural settlement pattern. In the reviewed studies different factors have been surveyed as affecting factors, while in none of these studies the role of underground waters has been pointed out. While it is one of the most important factors in the formation of spatial pattern and size of rural settlements in semi-arid areas such as Qazvin province. In the present study the impact of this factor on the formation of rural settlements pattern of the province has been examined. Moreover, SKATER method has been used in this study, while it has not been used in any similar research so far (Figure 1).

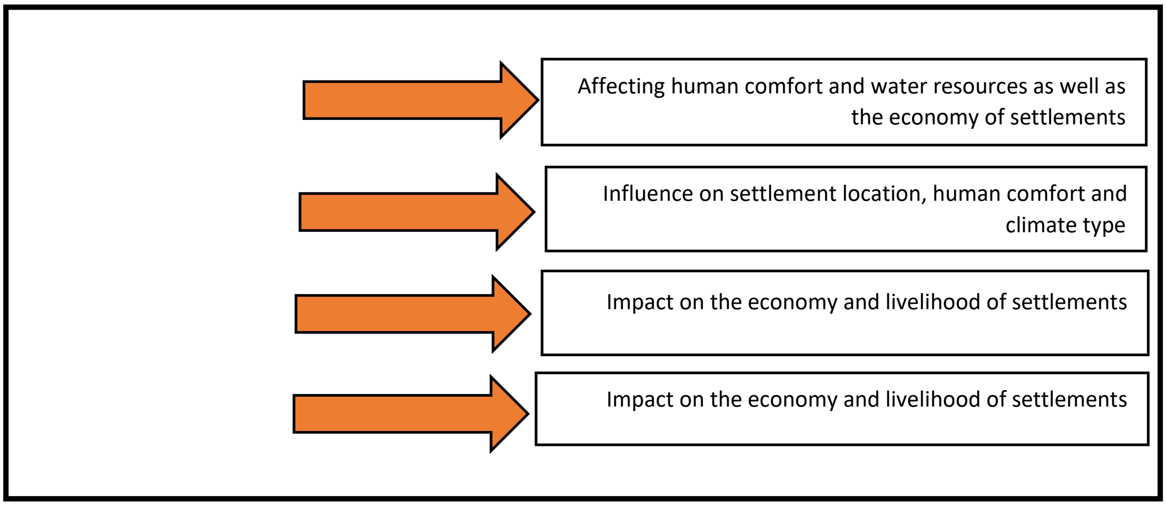

Figure 1. The impact of ecological factors on spatial patterns of rural settlements

3. Research Methodology

The data used in this research are of two categories: the first category is the demographic data of rural areas of Qazvin province which belong to general population and housing census from 1976 to 2016. The second category is the spatial data (map) related to ecological factors of the province that include the following: digital elevation model (DEM) of Qazvin province which is provided by ALOS/ PALSAR sensor and has a spatial resolution of 12.5 meters. shp layer location point of villages of Qazvin province, linear shp layer of rivers and waterways of Qazvin province, polygonal shp layer of soil type of Qazvin province, polygonal shp layer of climate, precipitation and temperature of Qazvin province.

The descriptive-analytical method has been used in this study. First, Getis-Ord Gi* statistic was used to examine the spatial pattern of rural settlements of Qazvin province. The hot spot analysis calculates Getis-Ord Gi* statistic for all features of a layer based on a certain feature. This tool analyzes the characteristic of each feature in ratio with the features of its neighbor. A feature associated with a specific characteristic may have a high value on its own, but it may not be a significant point in terms of hot spot analysis. For a point to be statistically significant, a characteristic must have a high value and be surrounded by other features that also have high value.

The Getis-Ord Gi* statistic is calculated in the following way:

$$G_i^* = \frac{\sum_{j=1}^{n} \omega_{i,j} x_j - \bar{X} \sum_{j=1}^{n} \omega_{i,j}}{S \sqrt{\frac{\left[n \sum_{j=1}^{n} \omega_{i,j}^2 - \left(\sum_{j=1}^{n} \omega_{i,j}\right)^2\right]}{n-1}}}$$

In this formula x_j is the value of the characteristic for the feature, $\omega_{i,j}$ which is the spatial weight between features i and j and n is the number of total features. $\bar{X}$ and S are calculated as follows:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

Since Gi is a kind of Z in itself, there is no need to calculate it again (Asgari, 2010).

Then in order to examine the relationship between ecological factors and the spatial pattern of rural population of the province, the rural areas were grouped based on the ecological conditions and in the following, the relationship between this grouping and the spatial distribution of the population of rural areas has been investigated using a comparative method analysis.

Spatial 'k'Luster Analysis by tree Edge Removal (SKATER) method was used to group rural areas based on the ecological conditions. SKATER algorithm was presented in 2006 by Assuncao et al. this method is made based on the cutting of tree branches, as a weighted connection graph with edges and nodes, and it clusters (groups) the values

according to their location. In this method clusters with similar values are expected to be next to each other. In this method for each region or area, a list of connected neighbors is presented and the cost for each neighbor is calculated, i.e. the total distance between all variables attached to regions or points is calculated. A two nearest neighbor algorithm (in terms of data) is selected for each region or point, and finally areas are grouped into the most consistent spatial clusters (Assuncao et al., 2006).

To learn more about this method, we must first learn about clustering. Consider *n* as place with *s* as the observed variable in any location. In equation 1, any specific location has different features in which the purpose of spatially constrained clustering is to create k spatially connected regions that are homogeneous with respect to X. in spatial clustering, if the areas are similar in value and close in space, they can be assigned to one cluster.

$$X = \begin{bmatrix} | & | & & | \\ x_1 & x_2 & \dots & x_n \\ | & | & & | \end{bmatrix}$$

Therefore, spatial relations should be considered in every zoning algorithm. In spatial statistics, spatial relations are shown using spatial weight matrices (Aldous, 1990; Assuncao et al. 2006). Spatial weight matrices were given in equation 5.

$$A = \begin{bmatrix} 0 & & a_{1,n} \\ a_{2,1} & \ddots & a_{2,n} \\ a_{n,1} & & 0 \end{bmatrix}$$

In which, ai,j is an index variable for location I and the neighborhood of j with ai,j=ai,j. the neighborhood relations are defined as follows:

$$a_{i,j} = \begin{cases} 1, & d_{euc}(i,j) \le \epsilon \\ 0, & d_{euc}(i,j) > \epsilon \end{cases}$$

Equation 6 identifies two locations i and j as neighbors, if they are in a specific distance ϵ considering the metric distances such as Euclidean distance deuc. However, there is a conceptualization which is different from spatial relations such as k neighbors and neighborhood proximity-based algorithms (Getis, 2009; Geris and Aldstadt, 2010). Zoning (grouping or clustering) can be stated as a limited optimization issue to define groups of objects without breaking the spatial proximity according to A:

{R1, . . . ‹Rk} ∈ R.

$$\underset{R}{\arg\min} = \sum_{i=1}^{k} \sum_{j \in R_i} d\left(x_j, \mu_{R_i}\right)$$

$$\text{subject to} \sum_{j \in R_q} A[i,j] \ge 1 \qquad \forall i \in R_q, \forall q \in \{1, \dots, k\}$$

In which µRi is the mean for Ri region and d is the distance measurement which is often used as Euclidean distance. The optimization issue in equation 7 requires finding R regions so that the values within a zone are homogeneous and locations of the values are connected. We define a general operator as:

$$\mathcal{L}(X.A): \rightarrow R \text{ where } R = [R_1 \dots R_k]$$

An efficient $\mathcal{L}(X.A)$, ‹$\mathcal{L}(X)$ which is based on spatial constraints of A does not require case setting in spatial clustering (Carlos Duque et al. 2007). One of the efficient zoning approaches is to display A and X jointly and use the efficient clustering algorithm in this new display.

Graph partitioning is an approach for defining an efficient $\mathcal{L}$. In this approach location information has been displayed using a (4) weighted and undirected graph. G (V, E, L). The location of space objects is shown by vertices, V = V (G) = {v1‹.... vn } in which |V (G) | = n and neighborhood relations between spatial objects have been shown with edges and |E (G) | = m is the number of neighbor pairs. The similarity between observed variables in each node is displayed in the form of paired edge weights (wi,j). Edge weight (wi,j) for edge ei, jєE(G) is defined by distance function based on the feature vector x_i for object i, *and* $d(x_i.x_j)$.

Displaying the spatial object graph allows partition operators to be used in grouping and meanwhile preserve the constraints of spatial proximity. General zoning operator which works on a G graph, is displayed as follows:

$$\mathcal{L}(G) = G^* = \{R1 \dots . Rk\}$$

The subgraph $G^* \subset$ G, where |V (G∗) | = n, consists of spatially adjacent regions R = { R 1. .... Rk } . Notably, G − $G^* = E_{cut}$ where E_{cut} is the set of edges removed to divide G into spatially connected regions. In figure 1 a graph-

based approach has been used for spatially constrained clustering.

$\mathcal{L}$ Creation operator defines the spatial adjacent areas for the data of figure 2. The main G graph is depicted on the main set of data and the divided G* graph is located on the zoning output.

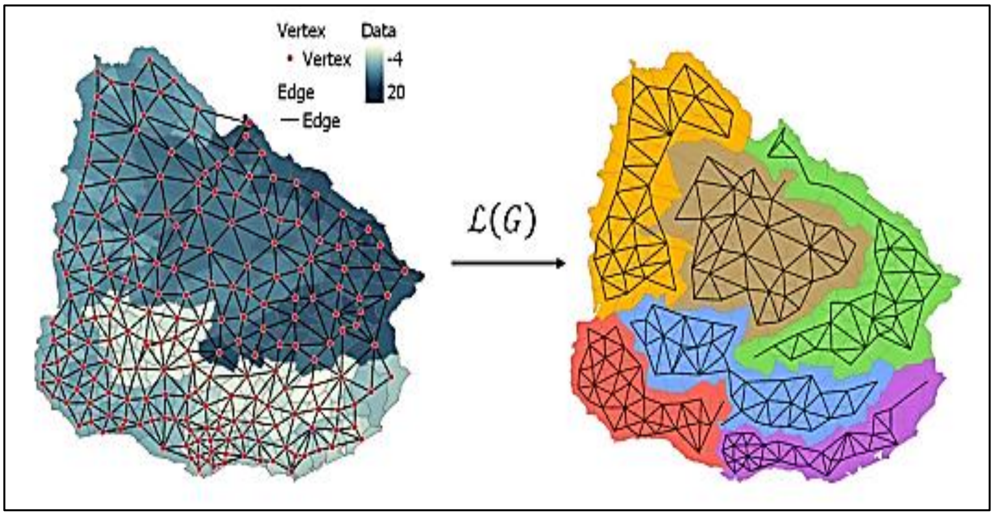

Figure 2. graphic display of spatial data (left side) and the map of the region with spatially constrained clustering (right). The divided subgraph is located on the (right) areas. (Assuncao et al. 2006)

The only difference between G and G* are *Ecut* edges. The edges are omitted to define R. various criteria identify different methods of *Ecut* and the quality of produced zoning is dependent on *Ecut*. The general quality criterion for zoning is the homogeneity of values in each region. The general homogeneity index $f_h(G^*)$ is presented in equation 10:

$$f_h(G^*) = \sum_{i=1}^{k} \sum_{j \epsilon R_i} d(x_j . \mu(R_i))$$

In this equation $d(x_j . \mu(R_i)$ measuring the changes of each region is done considering some central criteria $\mu(R_k)$ related to R_k area such as mean and median.

Finding optimized *Ecut* which maximizes equation 10, is a computationally intensive work, especially for large sets of data (or in other words for large m) that are well connected. A branch of graph-based approaches for zoning (grouping) uses the spanning tree protocol to reduce the number of edges to search from *m* to *n* (Assuncao et al. 2006; Maravalle & Simeone, 1995). Due to the spatial problems of $n \ll m$, the tree-based approaches in the category of graph-based zoning methods have become very popular. To reduce the problem of spatial constrained clustering Assuncao et al. have suggested tree segmentation method through using spanning tree T (Assuncao et al., 2006). Assuncao's spatial clustering analysis algorithm uses the minimum spanning tree by tree edge removal (SKATER). $T_{MST}(V.E)$ in which $V(T_{MST}) = G$ and $E(T_{MST}) \subset E(G)$ in which $|E(T_{MST)}| = n - 1$. SKATER algorithm uses T_{MST} as a route to inspect all spatial locations to define *Ecut*. This approach decreases the number of neighbors from *m* to *n – 1*.

Removing one edge T_{MST} leads to create two subtrees T^+_{MST} and T^-_{MST} on both sides of the removed edge. These subtrees indicate two zones. SKATER removes T_{MST} from the edges repeatedly and selects an edge that maximizes the equation 10. First, T_{MST} shows a region which is divided to k subtrees by SKATER, $T^* = \{T_1 \dots . T_k\}$ which covers the regions, $R = \{R_1 \dots . R_k\}$. Every time the objective function maximizes (the equation 7), SKATER removes one edge of T^*.

$$f_{obj}(e_{ij}) = f_h(T) - f_h(T^+) - f_h(T^-)$$

Equation 11 quantifies the change in homogeneity by dividing the indicated area T to two zones T^+ and T^-. Assunsao et al. define fh as whithin-

cluster squared deviation (SSD) in which the homogeneity is quantified based on the deviation from regional average, $\mu(R_k)$. The SKATER algorithm is shown in figure 3.

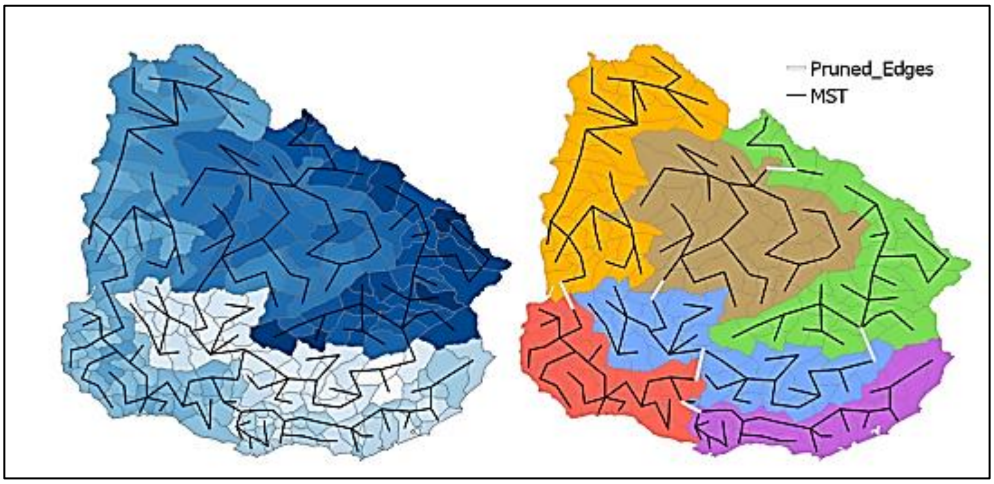

Figure 3. the location data is overlapped with the search path T_{MST}. (left side). The region map by tree edge removal (right side). The removed edges from T_{MST}. have been indicated with white color (Assunsao et al. 2006)

Figure 4 shows the location data and the related minimum spinning tree. The edges of the spinning tree are removed repeatedly (shown with white color) to define the zoning map (right side).

4. Research Findings

In order to identify the demographic changes of Qazvin province, in the first step, the demographic statistics of rural areas of the province were extracted according to census of Statistical Center of Iran during the years 1976-2016 and demographic map of rural settlements network during the census period was prepared, the results of which have been shown in figure 3:

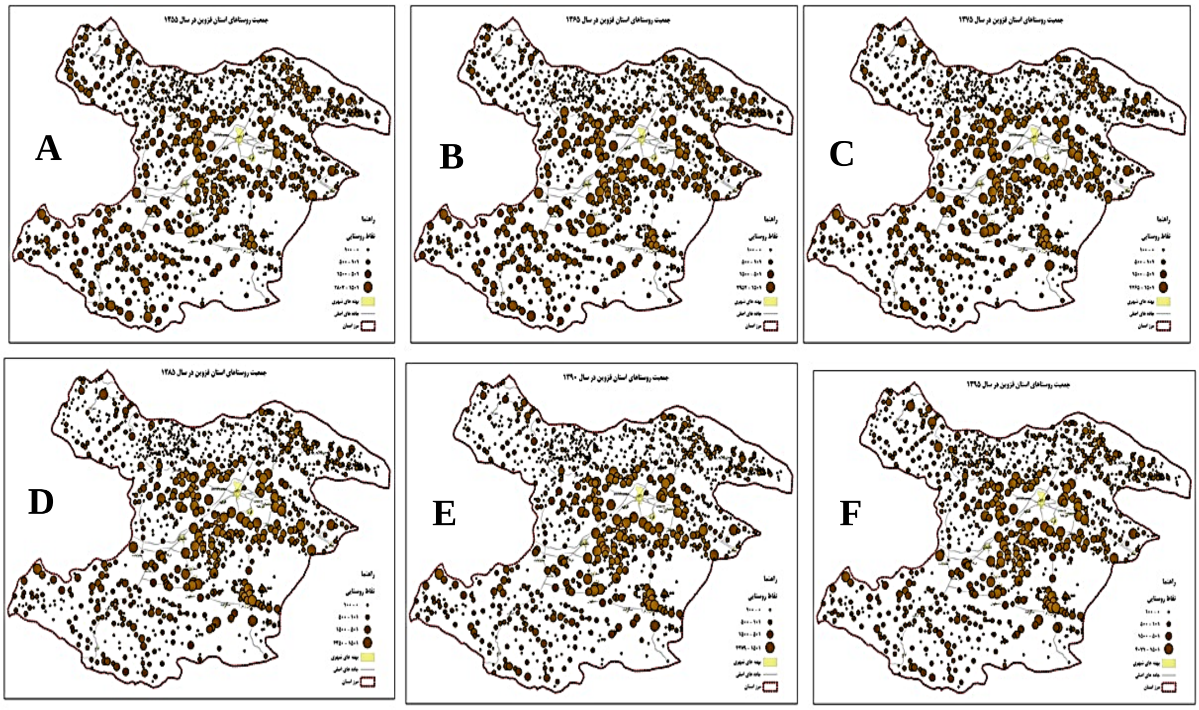

Figure 4. demographic changes of villages in Qazvin province during census A: 1976, B: 1986, C: 1996, D: 2006, E: 2011, and F: 2016

The rural population of Qazvin province was equal to 363911 people in 1976 and it reached 439921 people in 1986, which indicates an increase of 21%. The reason for the population increase during the period 1976-1986 can be related to the incentive policies of the population increase during this period. During the following periods the rural population of the province decreased, so that it reached 415329 people in 1996, 365225 people in 2006, 323324 people in 2011 and finally 321610 people in 2016. The decrease in rural population of the province is due to increased migration from the villages to cities.

Visual interpretation of the spatial distribution of the rural population of the province during the studied periods shows a tendency to concentrate the population in certain areas of the province. In 1976, the spatial distribution of the rural population in the province was almost uniform, while during the following periods, the level of uniformity decreased and density of the spatial distribution of the population occurred, such that it increased in the central and eastern regions of the province and decreased in other areas of the province.

Hotspot analysis method and calculation of Getis-Ord Gi* statistics were applied to review the spatial distribution of the rural population of the province, using ARC GIS software and the results have been indicated in figure 5.

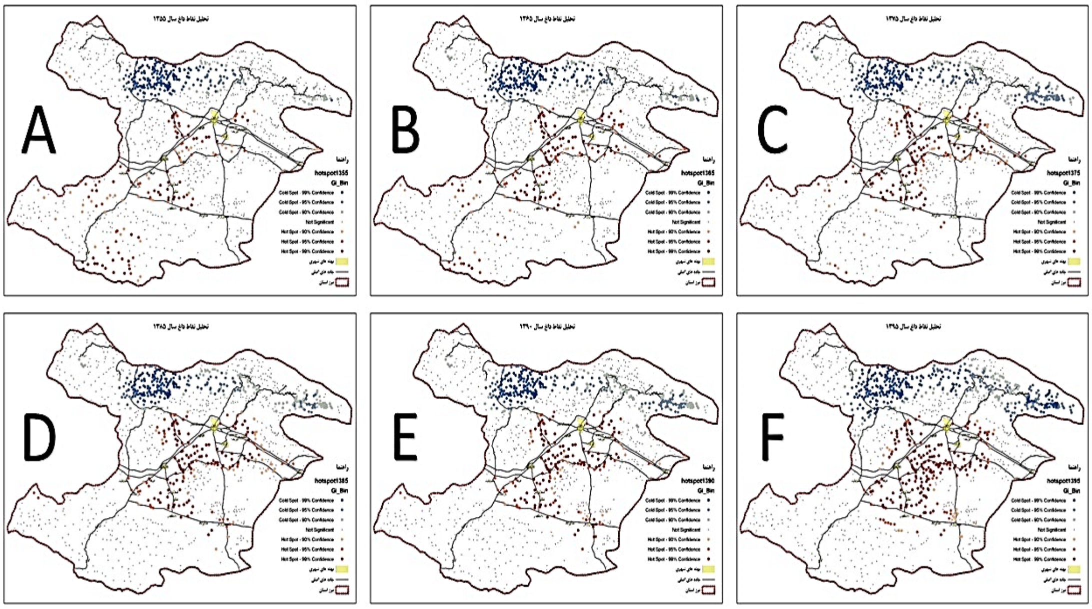

Figure 5. hotspot analysis of rural population of Qazvin province during the census periods A: 1976, B: 1986, C: 1996, D: 2006, E: 2011, and F: 2016

The Z-scores of the values higher than 1.96 are statistically significant with the coefficient of 90-99 and are shown with red color. In this study they indicate the high density of the population which during different periods of population and housing census have formed clusters with hot spots in various parts of the province. The negative value of -1.96 and below are statistically less significant and shown with blue color, form cold spots and indicate the rural areas with low population density.

Figure 3 shows the results obtained from Getis-Ord Gi* statistics during the census period of 1976-2016. According to the results, in 1976, there were the most hot spots with a confidence level of 90%, mostly in central, southwestern, and southern areas of the province, and cold spots were also seen in the northern part of the province. In 1976, almost the same pattern was maintained, although with minor differences, among which we can point out the decrease in the number of hot spots in the southern part of the province and the significant increase in hot spots in the center of the province. In 1996, also the movement of the hot spots towards the center of the province increased. This pattern of increasing the number of spots and their significant increase in the hot spots of province

center continues during the following years and it shows the population concentration in this area during the following years. The northern part of the province which is its mountainous areas, contains the cold spots during the periods under study. These areas have increased during the years 2006-2016 and have advanced to the western parts of the province.

Reviewing the spatial distribution pattern of rural settlements of Qazvin province based on Getis-Ord statistics indicates a clustering pattern of spatial distribution of rural areas of the province. This pattern has a high density in some areas and low density in other regions. The central areas of the province including Qazvin plain consist of hot spots and northern areas of the province including mountainous areas consist of cold spots (figrue 6).

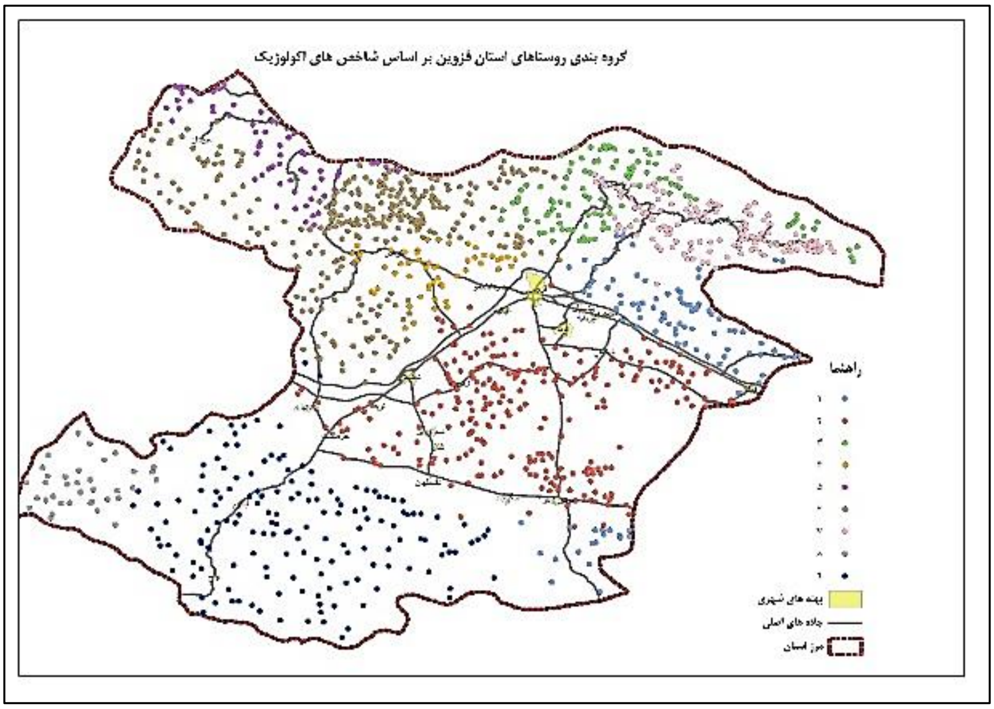

Figure 6. ecological grouping of villages of Qazvin province using SKATER method

Figure 4 indicates the grouping done by SKATER method for rural areas of Qazvin province. The rural areas of Qazvin province have been divided into 9 groups based on ecological conditions. These groups have been defined based on similar ecological conditions such as topography, slope, slope direction, distance from the river, precipitation, temperature, soil type, and access to underground waters. In SKATER method in addition to homogeneity of these conditions, spatial distance is also important in defining groups.

After grouping the rural areas of Qazvin province based on ecological conditions, table 1 and 2 were prepared in order to examine the impact of ecological conditions on the spatial pattern of rural settlements.

The percentage of population of each group of rural areas of the province during the population and housing census was identified in table 1. In 1976, the largest percentage of the rural population of the province (29%) lived in the villages of group 2 and the lowest percentage of it lived in the villages of groups 5 and 8 (4%). The second place in terms of population percentage belongs to the villages of group 9 with 21% of total population in 1976. In other words, it can be mentioned that, 50% of rural population of the province lived in groups 2, 5, and 8 and it shows a high population density in these groups of villages.

We can observe a lot of changes in terms of share amounts in 1986. For example, the increase in shares of the villages of group 2 to 34% indicates an increase of density in this group during this period. The shares of the villages in group 9 have decreased from 21% to 19%. The largest shares in this period are allocated to the villages of group 2 and the smallest shares of the total population belong to the villages of group 5

with 3 percent. In general, during the period 1976-1986 the share of the villages of groups 1, 2, and 4 in the total population have increased and the villages in groups 5, 6, 7, and 9 have faced a decrease in their shares of total population. The shares of the villages in groups 3 and 8 did not show any difference in ratio with previous period.

The largest share of the total population in 1996 is also allocated to the villages of group 2 (39%). Moreover, during this period the shares of the villages of this group from rural population of the province have increased by 5%. The lowest shares of population in this period are also allocated to the villages of groups 5 and 8 with 3 percent. During the period 1986-1996 there was an increase in the shares of groups 2 and 4 and a decrease in the shares of groups 3, 7, 8, and 9. The shares of groups 1, 5, and 6 did not change compared to the previous period.

Like former periods, in 2006, the largest share belongs to the villages of group 2 with 43% of total population. The lowest shares belong to groups 3, 5, and 7 with 3 percent. During the period 1996-2006 the shares of groups 1 and 2 have increased and the shares of groups 3, 6, 7, and 9 have decreased. The rest of the groups did not change compared to previous periods.

Like previous periods, the largest share in 2011 also belongs to group 2 with 45%. However, this is the only group whose share increases in ratio with the former period. Other groups either had a decrease in their shares such as groups 6 and 7 or had no change in their shares compared to previous period.

In 2016, which is the last census period, group 2 took the first place in terms of population share, as in the previous periods, and during 2011-2016, the share of the total rural population of the province increased by 2% and reached 47% in 2016. In addition to group 2, group 4 also had an increase of 1%, while other groups either had no change compared to the previous period or faced a decrease in share.

Table 1. distribution of population in the villages of Qazvin province during census period based on ecological grouping of the villages

Group number	Percentage of the total population (1976 census)	Percentage of the total population (1986 census)	Percentage of the total population (1996 census)	Percentage of the total population ((2006 census	Percentage of the total population (2011 census)	Percentage of the total population (2016 census)
Group 1	0.10	0.11	0.11	0.12	0.12	0.12
Group 2	0.29	0.34	0.39	0.43	0.45	0.47
Group 3	0.05	0.05	0.04	0.03	0.03	0.03
Group 4	0.06	0.07	0.08	0.08	0.08	0.09
Group 5	0.04	0.03	0.03	0.03	0.03	0.03
Group 6	0.13	0.10	0.10	0.08	0.07	0.06
Group 7	0.08	0.07	0.06	0.05	0.04	0.04
Group 8	0.04	0.04	0.03	0.03	0.03	0.03
Group 9	0.21	0.19	0.16	0.13	0.13	0.13

Table 2 indicates the population growth rate of the villages in various groups during census periods. According to the information given in this table the annual growth rate of rural population of Qazvin province has been positive only during the period 1976-1986 (1.9%) and the annual growth rate in the rest of studied periods was negative.

The growth rate of different groups showed that in the examined periods only group 2 had a positive population growth rate and other groups experienced trends almost similar to the growth of the province. The growth rate of group 2 during 1976-1986 was 3% and during the following periods reached 1, 0.3, 0.7 and 0.3 percent respectively.

The population growth trends in ecological groups indicates different status of group 2 in ratio with other groups.

Table 2. population growth rate in the villages of Qazvin province during census periods based on ecological grouping of villages

Group number	Population growth rate 1976-1986	Population growth rate 1986-1996	Population growth rate 1996-2006	Population growth rate 2006-2011	Population growth rate 2011-2016
Group 1	2.1	-0.3	-0.2	-0.4	0.1
Group 2	3.0	1.0	0.3	0.7	0.3
Group 3	0.6	-2.4	-2.4	-1.4	-0.2
Group 4	1.5	0.9	-0.3	-0.1	0.0
Group 5	-0.7	-0.4	-0.8	-0.5	-0.2
Group 6	-1.3	-0.1	-2.9	-2.9	-0.3
Group 7	0.5	-3.3	-1.7	-3.8	-0.4
Group 8	0.2	-1.5	-1.2	-1.3	-0.1
Group 9	0.4	-1.8	-2.7	-0.4	-0.3
All groups	1.3	-0.6	-1.3	-2.4	-0.1

In order to identify the effect of ecological factors on the spatial distribution of the villages of Qazvin province, the correlation coefficient between the villages' population and quantitative ecological factors during the studied periods were calculated and the output of this coefficient has been shown in table 3.

Table 3. Pearson correlation coefficient between the ecological factors and population of groups according to the years under study

		Access to the aquifer	Average distance to the river	Slope percentage	Height above sea level	Average annual temperature	Average annual precipitation
Population in 1976	correlation coefficient	.753*	-.675*	-0.407*	-0.009	0.063	-0.533
	Sig. (2-tailed)	0.019	0.046	0.027	0.982	0.872	0.140
Population in 1986	correlation coefficient	.851**	-.706*	-0.484*	-0.063	0.117	-0.561
	Sig. (2-tailed)	0.004	0.033	0.018	0.871	0.764	0.116
Population in 1996	correlation coefficient	.905**	-.725*	-0.523	-0.132	0.186	-0.595
	Sig. (2-tailed)	0.001	0.027	0.024*	0.734	0.632	0.091
Population in 2006	correlation coefficient	.937**	-.729*	-0.550*	-0.176	0.229	-0.596
	Sig. (2-tailed)	0.000	0.026	0.041	0.651	0.553	0.090
Population in 2011	correlation coefficient	.945**	-.730*	-0.568*	-0.183	0.238	-0.609
	Sig. (2-tailed)	0.000	0.025	0.031	0.637	0.538	0.082
Population in 2016	correlation coefficient	.951**	-.721*	-0.523*	-0.223	0.273	-0.602
	Sig. (2-tailed)	0.000	0.028	0.049	0.564	0.478	0.086
**The correlation coefficient is significant at the 0.01 level (2-tailed)							
*The correlation coefficient is significant at the 0.01 level. (2-tailed)							

According to the obtained coefficients, the most influential ecological factor on spatial distribution of population of the villages of the province during the studied periods, is access to underground waters (being located on the aquifer). The correlation coefficient of this factor with the population living in villages in 1976, is equal to 0.753 (with a significance level of 0.05). Throughout the following periods the correlation coefficient between this factor and rural population of ecological groups had an increasing trend and reached 0.951 (with significance level of 0.01) in 2016. The second important and effective factor is the distance from surface water resources (distance from rivers).The coefficient of this factor has also increased from -0.675 (with a significance level of 0.05) in 1976 to -0.721 (with a significance level of 0.05) in 2016. According to the regression coefficients outputs it can be said that, there is a very strong positive relationship between the factor of access to underground waters and spatial distribution of the population of the province, whose intensity has increased in the years under review. There is a strong negative relationship between the factor of distance from surface water resources and spatial distribution of the population of the province whose intensity has increased during the studied years. The relationship between the slope percentage and spatial distribution of the population is also strong and negative and its intensity has increased in the years under review. The relationship between other ecological factors and spatial distribution of the population of the province is not significant at the level of 0.01 and 0.05%. For the qualitative factors including geographical direction of the slope and the type of soil, the correlation relations of Fei, Kramer and Landa wer calculated, but no significant relationships were observed between these factors and the spatial distribution of the population.

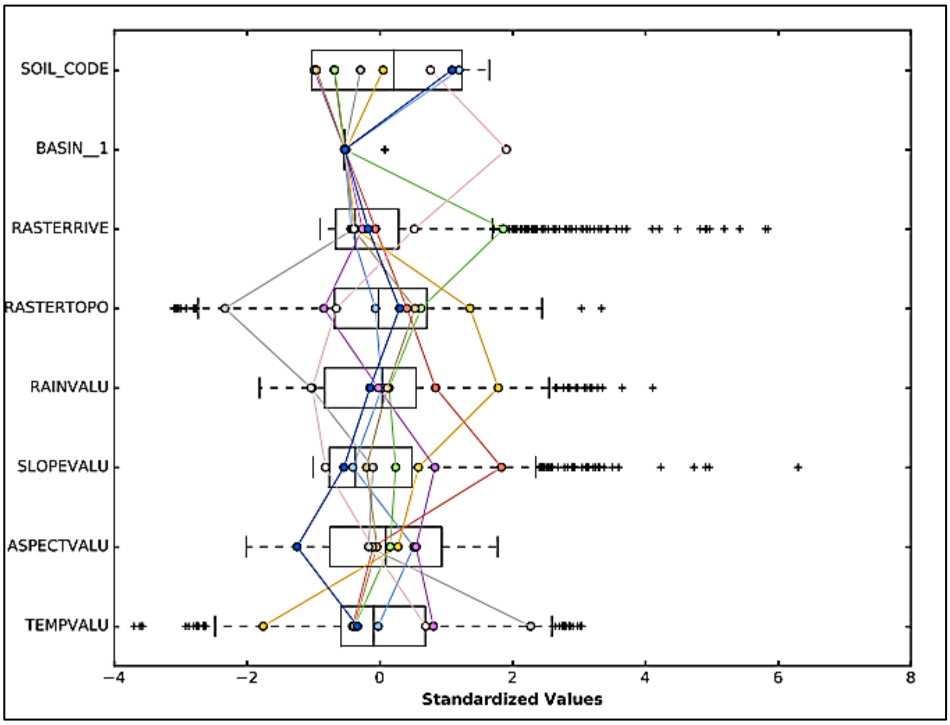

Figure 7. parallel box plot

One of the outputs of the grouping method used is the parallel box plot which can be observed in figure 7. In this diagram each line which has been shown with a different color is related to one of the groups of the villages and its ecological factors. As an example, in group 2 diagram (pink), item (CODE-SOIL) indicates the type of the soil, item (BASIN-1) shows the location of these groups of villages on Aquifer of the plain, (RASTERRIVER) shows the distance from the river (above the mean), item (RASTERTOPO) indicates the height (below the mean), item (RAINVALU) displays the amount of rainfall (below the mean), item (ASPECTVALU) indicates the dominant slope and finally item (TEPVALU) shows the temperature (above the mean). As observed in the diagram, the

main difference between group 2 and other groups which leads to high rate of population in this group and also its high share of population in the reviewed periods in ratio with other groups is related to factors such as being located on aquifer (access to underground waters), suitable slope (maximum 20%), and suitable distance from surface water resources (distance from the river).

5. Discussion and Conclusion

The present study was conducted with the aim of examining the role of ecological variables in the formation of rural settlements pattern in Qazvin province. The results obtained from this research can be reviewed in two parts: the first part has been related to the impact of the role of ecological factors in the formation of the pattern of rural settlements in Qazvin province. According to variance analysis test, the results of this part of the study showed that, the ecological factors are involved in the spatial distribution of rural settlements of the province and formation of the settlement pattern. In the meantime, factors such as access to underground water, distance from the river, and direction of the slope play a more prominent role. In almost all reviewed studies, factors such as distance from the river and the direction of the slope have been considered as important and influential ecological factors in the formation of spatial pattern of rural settlements. Therefore, in terms of the effectiveness of these factors, the findings of the present study are consistent with most previous studies. However, one of the most important findings of this study which has not been mentioned in previous studies, is the high impact of access to underground waters in the formation of spatial pattern and also demographic changes of Qazvin village network during the investigated periods. Water as a vital element has played a great role in accommodation of population in human settlements throughout history. It has a higher influence on rural settlements, since the employment and livelihood of their residents depend on this factor. And In the meantime, access to underground waters is one of the most important ecological variables which has an undeniable role in the formation of rural settlements pattern of the province and due to droughts in recent years, the role of this factor has become more prominent and has caused the population density in certain groups.

agricultural activities and gardening require access to sustainable resources and water. Since Qazvin is located in a semi-arid area, access to water in the settlements of this province is mainly through underground resources. The Qazvin plain aquifer is one of the most important underground water resources of this province which has a major role in supplying water for rural settlements of Qazvin province. Due to lack of rainfall in recent years, and reduction of surface water resources in the whole country and also Qazvin province, the dependence on underground resources to supply water to rural settlements has been increased. This issue has intensified the role of this factor in the formation of spatial patterns of rural settlements during the studied periods, especially the final courses.

The second part of the results is related to the methods used in this study. The results obtained from the SKATER method in grouping rural areas of Qazvin province according to ecological conditions prove the efficiency of this method in research related to the field of residential pattern studies. The results also show that combining the above method with statistical methods can make an efficient and influential system which brings positive results.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

The authors equally contributed to the preparation of this article.

Conflict of interest

The author declares no conflict of interest.

References

1. Aldous, D. (1990). A random tree model associated with random graphs. *Random Structures & Algorithms*, 1(4), 383–402. https://doi.org/10.1002/rsa.3240010402
2. Aliaee, M.S. (2018). Investigating the role of natural factors in the distribution and establishment of rural settlements in Zanjan county. *Land Geographical Engineering*, 3(5), 45-57. [In Persian]. http://www.jget.ir/article_93452.html

3. Asgari, A. (2010). *Spatial statistical analysis with ArcGIS*. Technology and Communication Organization of Tehran Municipality. [In Persian].
4. Assunção, M.R., Corrêa Neves, M., Câmara, G., & da Costa Freitas, C. (2006). Efficient regionalization techniques for socio-economic geographical units using minimum spanning trees. *International Journal of Geographical Information Science*, 20, 7, 797–811. http://dx.doi.org/10.1080/13658810600665111
5. Bahrami, A., Rezalu, R. & Aftab, A. (2017). Role of natural factors in the ecological distribution of ancient habitats in Ardabil province. Geographical space, 17 (57), 157-139. [In Persian].
6. http://geographical-space.iau-ahar.ac.ir/article-1-692-fa.html
7. Carlos Duque, J., Ramos, R., & Suriñach, J. (2007). Supervised regionalization methods: A survey. *International Regional Science Review*, 30(3),195–220. https://doi.org/10.1177/0160017607301605
8. Chen, S., Mehmood, M.S., Liu, S., & Gao, Y. (2022). Spatial Pattern and Influencing Factors of Rural Settlements in Qinba Mountains, Shaanxi Province, China. *Sustainability*, *14*, 10095.
9. http://doi.org/10.3390/su141610095
10. EstelaJi, A.R., & Jafari, M. (2014). Role of natural factors in the spatial arrangement of rural settlements in Mahenshan county. *Geography and Environmental Studies*, 3(10), 29-40. [In Persian]. http://ges.iaun.iau.ir/article_555726.htm
11. Fazli Nashli, H., Darabi, H., Fallahian, Y., & Naseri, R. (2011). Absolute and relative chronology of Segzabad hill, Qazvin plain. *Archaeological Studies*, 3(1), 133-158. [In Persian]. http://jarcs.ut.ac.ir/article_28699.html
12. Getis, A., & Aldstadt, J. (2010). Constructing the spatial weights matrix using a local statistic. *In Perspectives on spatial data analysis. Springer*, 147–163. http://dx.doi.org/10.1007/978-3-642-01976-0_11
13. Getis, A. (2009). Spatial weights matrices. Geographical Analysis 41, 4,404–410.
14. http://doi.org/10.1111/j.1538-4632.2009.00768.x
15. Guanghui, J., Fengrong, Z., & Junwei, C. (2007). Analysis of the driving forces of change of rural residential areas in Beijing mountainous areas based on Logistic regression model. *Transactions of the Chinese Society of Agricultural Engineering (Transactions of the CSAE)*, *23*(5), 81-87. http://www.tcsae.org/nygcxben/article/abstract/20070514
16. Liu, Y., Ke, X., Wu, W., Zhang, M., Fu, X., Li, J., ... & Zhou, X. (2022). Geospatial characterization of rural settlements and potential targets for revitalization by geoinformation technology. *Scientific reports*, *12*(1), 1-16. http://doi.org/10.1038/s41598-022-12294-2
17. Ma, L., Guo, X., & Zhang, Q. (2012). Spatio-temporal distribution and optimization of rural settlements in Gangu county of loess hilly area. *Nongye Gongcheng Xuebao.Transactions of the Chinese Society of Agricultural Engineering*, 28, 217 - 225. https://www.ingentaconnect.com/content/tcsae/tcsae/2012/00000028/00000013/art00035
18. Maravalle, M., & Simeone, B. (1995). A spanning tree heuristic for regional clustering. *Communications in statistics-theory and methods*, 24, 3,625–639. http://doi.org/10.1080/03610929508831512
19. Motiee Langroudi, S.H., Faraji Sobkbar, H.A., Qadiri Masoum, M., & Bakshi, Z. (2016). Spatial analysis of the distribution of rural settlements in the Sabzevar-Nishabour region based on the available ecological resources. *Human Geography Research*, 49(1), 227-242. [In Persian]. http://Doi.10.22059/jhgr.2017.59773
20. Mousavi Kohper, S.M., Heydarian, M., Aghaari Heer, M., Vahdati Nasab, H., Khatib Shahidi, H., & Nistani, J. (2011). Analysis of the role of natural factors in the spatial distribution of ancient sites in Mazandaran province. *Natural Geography Research*, 43(75). [In Persian] http://jphgr.ut.ac.ir/article_22629.html
21. Mousavi, M., Nazmfar, H., & Aftab, A. (2012). Investigating the role of natural factors in the geographical distribution of population and urban settlements using GIS and Geoda, case study: West

Azarbaihan province. *Geography and Environmental Studies*, 2(5), 80-98. [In Persian]. http://ges.iaun.iau.ir/article_552355.html
22. Nematullahi, F., & Ramesht, M.H. (2021). Spatial analysis of rural settlements in Iran. *Geography and Development*, 19(65), 1-26. [In Persian]. http://doi:10.22111/j10.22111.2021.6519
23. Qiu, L., He, D., & Jiang, S. (2019). GIS-based spatial distribution characteristics and influence factors of rural residential area in ChongyiCountry (in Chinese with English abstract). *Anhui Agric. Sci. Bull*, 25(20), 1–4. http://doi.org/10.16377/j.cnki.issn1007-7731.2019.20.001
24. Rezaei, M.H. (2016). Role of environmental factors on the formation of Bakun period settlements in Kazeroon plain, south of Iran. *Archaeological Researches of Iran*, 7(14), 7-24. [In Persian]. http://doi:10.22084/nbsh.2017.11288.1485
25. Sadr Mousavi, M., Talebifard, R., & Niazi, C. (2016). investigating the role of natural factors in the geographical distribution of rural settlements (case study: Sahne county). *Human Settlements Planning Studies Quarterly (Geographical Perspective)*, 12, 4, 41. [In Persian].
26. http://jshsp.rasht.iau.ir/article_538273.html
27. Saeedi, A. (2009). Introduction of Rural Geography, Tehran: SAMT Publication. [In Persian]
28. Shahi, D. K. (2021). Distribution of rural settlements in the high himalayan region: A case study of har ki dun. ACADEMICIA Int. *Multi-discip. Res. J.*, 11(12), 285–294. http://doi.org/10.5958/2249-7137.2021.02698.7
29. Shakoei, H. (2010). Philosophy of Geography. Tehran: Gitasheasi Publication. [In Persian].
30. Tao, T., Abades, S., Teng, S., Huang, Z. Y., Reino, L., Chen, B. J., ... & Svenning, J. C. (2017). Macroecological factors shape local-scale spatial patterns in agriculturalist settlements. *Proceedings of the Royal Society B: Biological Sciences*, 284(1866), 20172003. https://doi.org/10.1098/rspb.2017.2003
31. Wang, X., Qi, W., & Liu, S. (2020). Spatial distribution characteristics and related factors of small towns in China (in Chinese with Englishabstract). *Geogr. Res*, 39(2), 319–336.
32. http://doi.org/10.11821/dlyj020190173
33. Xu, J., Yang, M., Lu, Z., Liu, D., & Wu, Y. (2021). Quality Analysis on Spatial Planning Pattern of Rural Area in Southern Shaanxi, China. *Sustainability*, *13*(22), 12668. http://doi.org/10.3390/su132212668
34. Xue-lan, T., Jian-nan, D., Yu-hang, X., & Chun-hong, B. (2010, December). A GIS based analysis of influencing factors of spatial distribution of rural settlements. In The 2nd International Conference on Information Science and Engineering (pp. 3416-3419). IEEE. http://doi.10.1109/ICISE.2010.5688941
35. Zhang, L., Lin, X., Leng L., & Zeng, Y. (2021). Spatial distribution of rural population from a climate perspective: Evidence from Jiangxi Province in China. *PLoS ONE,* 16(3): e0248078.
36. http://doi.org/10.1371/journal.pone.0248078
37. Zhang, H., & Zhang S, Liu, Z. (2020). Evolution and influencing factors of China's rural population distribution patterns since 1990. PLOS ONE 15(5): e0233637. http://doi.org/10.1371/journal.pone.0233637

Journal of Research and Rural Planning
Volume 12, No. 2, Spring 2023, Serial No. 41, Pp. 59-77
eISSN: 2783-2007 **ISSN: 2783-2791**
http://jrrp.um.ac.ir
Original Article

واکاوی تغییرات در الگوی فضایی شبکه سکونت‌گاه‌های روستایی استان قزوین با تاکید بر نقش عناصر اکولوژیک طی دوره ۱۳۹۵-۱۳۵۵

اکبر محمدی [۱*]

۱- استادیار مرکز آموزش عالی فنی و مهندسی بویین زهرا، گروه معماری و شهرسازی، بوئین زهرا، قزوین، ایران

چکیده مبسوط

۱. مقدمه

مکان گزینی و ا ستقرار سکونت‌گاه‌های بـ شری از ابتدای تاریخ بـ شر به‌عنوان یکی از مهم‌ترین دغدغه‌های انسان بوده است در ایجاد و مکان گزینی اولین سکونت‌گاه‌های ثابت انسانی نقش عوامل اکولوژیکی خیلی بارز می‌باشد. علی‌رغم پیشرفت‌های فنی صورت گرفته در دوره‌های بعد از باستان هنوز هم نقش عوامل اکولوژیکی پررنگ و غیرقابل‌انکار می‌باشد. البته اثرگذاری عوامل اکولوژیک را بیشتر در سکونت‌گاه‌های روستایی می‌توان مشاهده کرد تا سکونت‌گاه‌های شهری، چون ساختار فعالیت و معیشت در سکونت‌گاه‌های روستایی بیشتر به طبیعت و منابع آن وابسته می‌باشد. بررسی اولیه و مقدماتی توزیع سکونت‌گاه‌های روستایی استان نشانگر یک الگوی خاص (تمرکز روستاهای پرجمعیت در برخی پهنه های استان و خالی بودن از جمعیت بودن برخی روستاهای دیگر) در این استان می‌باشد که در طی دوره‌های مختلف سرشماری با تغییراتی همراه بوده است و این سؤال را به ذهن متبادر می سازد که چه عواملی باعث ایجاد چنین الگویی گردیده ا ست؟ آیا عوامل اکولوژیک در شکل‌گیری چنین الگویی نقش دارند؟ و اگر نقش دارند میزان اثرگذاری آن‌ها چقدر می‌باشد؟ به همین منظور تحقیق حاضر در جستجوی دست‌یابی به این سؤالات می‌باشد.

۲. مبانی نظری تحقیق

الگوی اسکان در سکونت‌گاه‌های روستایی هر منطقه بیش از هر چیز انعکاسی از ویژگی‌های محیط طبیعی (آب‌وهوا، پوشش گیاهی، محیط‌زیست، شیوه د ستر سی به منابع آب‌وخاک، پراکندگی مکانی شبکه آب‌ها و کیفیت خاک) ا ست. در زمینه تأثیر شرایط اکولوژیک بر الگوی سکونت‌گاه‌ها و به‌ویژه سکونت‌گاه‌های رو ستایی تحقیقات زیادی صورت پذیرفته است. در یک جمع‌بندی کلی می‌توان گفت که عوامل اکولوژیکی مؤثر در الگوی فضایی سکونت‌گاه‌ها به‌ویژه سکونت‌گاه‌های رو ستایی بر ا ساس مطالعات صورت گرفته شامل عوامل و متغیرهای اقلیمی، ارتفاع، شیب، جهت شیب، منابع آب و نوع خاک می‌باشند. در برخی از مطالعات به کاربری اراضی اشاره گردیده ا ست که به نظر می‌ر سد کاربری ارا ضی به‌عنوان یک پدیده حاصل از عوامل اکولوژیک بوده و نمی‌توان آن را به‌عنوان یک عامل اکولوژیکی به‌حساب آورد.

۳. روش تحقیق

داده‌های موردا ستفاده در این تحقیق دود سته می‌با شد: د سته اول داده‌های جمعیتی نقاط رو ستایی ا ستان قزوین می‌با شد که مربوط سر شماری‌های عمومی نفوس و مـ سکن سال‌های ۱۳۵۵ تا ۱۳۹۵ است. دسته دوم داده‌های فضایی (نقشه) مربوط به عوامل اکولوژیک ا ستان می‌با شد. روش موردا ستفاده در این تحقیق روش تو صیفی-تحلیلی می‌باشد. در ابتدا برای بررسی الگوی فضایی شبکه سکونت‌گاه‌های روستایی استان قزوین از آماره Getis-Ord Gi* و برای گروه‌بندی نقاط روستایی بر اساس شرایط اکولوژیک هم از روش تحلیل خو شه‌بندی فـ ضایی با حذف یال درخت (SKATER) استفاده گردیده است و در ادامه رابطه این گروه‌بندی با توزیع فضایی جمعیت نقاط روستایی با روش مقایسه‌ای و استفاده از تحلیل واریانس یک‌طرفه ANOVA بررسی‌شده است.

۴. یافته‌های تحقیق

بررسی الگوی توزیع فضایی سکونت‌گاه‌های روستایی استان قزوین بر اساس آمار گتیس-ارد نشانگر الگوی خوشه‌ای توزیع فضایی جمعیت در نقاط روستایی استان می‌باشد که این الگو در برخی از پهنه‌ها

*. نویسندۀ مسئول:
دکتر اکبر محمدی
آدرس: گروه معماری و شهرسازی دانشکده معماری، مرکز آموزش عالی فنی و مهندسی بویین زهرا ، بویین زهرا، ایران.
پست الکترونیکی: Email: a.mohammadi@bzte.ac.ir

دارای تراکم بالا و در برخی از پهنه‌ها دارای تراکم پایین بوده است. پهنه‌های مرکزی استان که دربرگیرنده دشت قزوین می‌باشد شامل لکه‌های داغ و پهنه‌های شمالی استان که دربرگیرنده مناطق کوهستانی است شامل لکه‌های سرد می‌باشد. گروه‌بندی نقاط روستایی استان قزوین بر اساس شرایط اکولوژیک در ۹ گروه انجام گردیده است. این گروه‌ها بر اساس شرایط اکولوژیکی مشابه مانند توپوگرافی، شیب، جهت شیب، فاصله از رودخانه، بارش، درجه حرارت، نوع خاک و دسترسی به سفره های زیرزمینی آب تعریف شده‌اند. بررسی شاخص‌های سهم از جمعیت کل روستایی و همچنین نرخ رشد جمعیت در گروه های اکولوژیکی روستاها تفاوت‌های عمده بین گروه‌ها را نشان داد که بیانگر اثرگذاری عوامل اکولوژیکی در این تفاوت‌ها می‌باشد. نتایج به‌دست‌آمده از آزمون تحلیل واریانس ANOVA هم بیانگر معناداری تفاوت در میانگین‌های جمعیتی گروه‌های اکولوژیکی است. بر اساس یافته‌های کلی بالاترین میزان تأثیر در گروه‌بندی مربوط به وجود آبخوان بوده و در رتبه‌های بعدی فاصله از رودخانه و جهت شیب قرار دارند که نشانگر تأثیر بالای این متغیر های اکولوژیکی در توزیع جمعیت روستایی استان در طی دوره‌های مختلف بوده است. در این میان نقش دسترسی به آب‌های زیرزمینی یکی از مهم‌ترین متغیرهای اکولوژیکی بوده که نقش انکار ناپذیری در شکل‌گیری الگوی سکونتگاه‌های روستایی استان داشته و به دلیل خشک سالی‌های روی‌داده در سال‌های اخیر نقش این عامل پررنگ‌تر گردیده و باعث تمرکز جمعیت روستاها در این گروه خاص گردیده است.

۵. بحث و نتیجه‌گیری

نتایج به‌دست‌آمده از این تحقیق را می‌توان در دو بخش موردبررسی قرارداد: بخش اول مربوط به تأثیرگذاری نقش عوامل اکولوژیک در شکل‌گیری الگوی سکونت‌گاه‌های روستایی استان قزوین بوده است در این بخش نتایج تحقیق با توجه به آزمون تحلیل واریانس نشان داد که عوامل اکولوژیک در توزیع فضایی جمعیت روستایی استان و شکل‌گیری الگوی سکونت‌گاهی نقش دارند و در این میان عواملی مثل دسترسی به آب‌های زیرزمینی، فاصله از رودخانه و جهت شیب نقش‌شان بارزتر می‌باشد. بخش دوم نتایج این تحقیق را می‌توان در خصوص روش مورداستفاده در تحقیق بیان نمود. نتایج به‌دست‌آمده از روش SKATER در گروه‌بندی نقاط روستایی استان قزوین بر اساس شرایط اکولوژیکی کارآمدی این روش را در تحقیقاتی که مربوط به حوزه مطالعات الگوی سکونتگاهی می‌باشد را اثبات می‌نماید

کلیدواژه‌ها: : الگوی فضایی، سکونت‌گاه‌های روستایی، عوامل اکولوژیک، روش SKATER، استان قزوین.

تشکر و قدردانی

پژوهش حامی مالی نداشته و حاصل فعالیت علمی نویسندگان بوده است.

Use your device to scan and read the article online	**How to cite this article:** Mohammadi, A. (2023). Investigating the changes in spatial pattern of rural settlement network of Qazvin province with the emphasis on the role of ecological elements during the period 1976-2016. *Journal of Research & Rural Planning*, *12*(2), 55-72. http://dx.doi.org/10.22067/jrrp.v12i2.2207-1054	**Date:** *Received: 30-10-2022* *Revised: 22-12-2022* *Accepted: 12-02- 2023* *Available Online: 12-02-2023*